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SPACE SHUTTLE PROGRAM
Space Shuttle Projects Office (MSFC)
NASA Marshall Space Flight Center, Huntsville, Alabama

Reusable Solid Rocket Motor

STS-108 Flight Readiness Review/CoFR

Motor Set RSRM-82

15 November 2001

Presented by Terry Boardman

THIOKOL PROPULSION

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Agenda

Flight Readiness Review/CoFR

1.0 Previous Flight Assessment—STS-105

2.0 Certification Status—**No Constraints**

3.0 Changes Since Previous Flight—**None**

4.0 Configuration Inspection

- 4.1 As-Built Versus As-Designed, Hardware, and Closeout Photo Review Status—**No Issues**
- 4.2 Hardware Changeouts Since ET/SRB Mate Review—**None**

5.0 SMRB Nonconformances—**None**

6.0 Technical Issues/Special Topics

7.0 Readiness Assessment

Backup LCC and Contingency Temperatures for STS-108

Previous Flight Assessment—STS-105

Disassembly Evaluation Summary—Status of Disassembly Activity

KSC Operations		LH RSRM	RH RSRM	Remarks
Initial LH/RH SRB viewing	*	Complete	Complete	
SRB/RSRM walkaround assessment	*	Complete	Complete	
Demate/evaluate aft exit cone (AEC)	*	Complete	Complete	
Remove/evaluate S&A and OPTs	*	Complete	Complete	
Remove/evaluate nozzle	*	Complete	Complete	
Remove/evaluate stiffener rings/stubs		Complete	Complete	
Remove/evaluate igniter	*	Complete	Complete	
Demate/evaluate field joints/evaluate insulation	*	Complete	Complete	
Utah Operations				
Disassemble/evaluate nozzle (joint No. 4 and 5)	*	Complete	Complete	
Disassemble/evaluate nozzle (joint No. 2 and 3)	*	Complete	Complete	
Disassemble/evaluate S&A	*	Complete	Complete	
Washout nozzle phenolics		Complete	Complete	
Washout nozzle AEC phenolics		Complete	Complete	
Measure/evaluate aft dome insulation		22 Feb 2002	22 Feb 2002	
Measure/evaluate LH segment and igniter insulation		22 Feb 2002	N/A	

* RSRM Project committed to complete prior to next launch

- **No constraints to STS-108 flight**

Technical Issues/Special Topics

STS-108 RH Nozzle Throat Carbon/Phenolic Material Performance

Observation

- While being irradiated in the Laser Hardening Materials Laboratory (LHMEL) at Wright-Patterson AFB, carbon-cloth phenolic (CCP) test specimens exhibited unexpected pocketing erosion behavior
  - Material was from Lot 3206, Roll 27A, used in the manufacture of the STS-108 RH nozzle throat

Concern

- Do test results indicate potential for anomalous nozzle throat thermal performance in flight?

Background

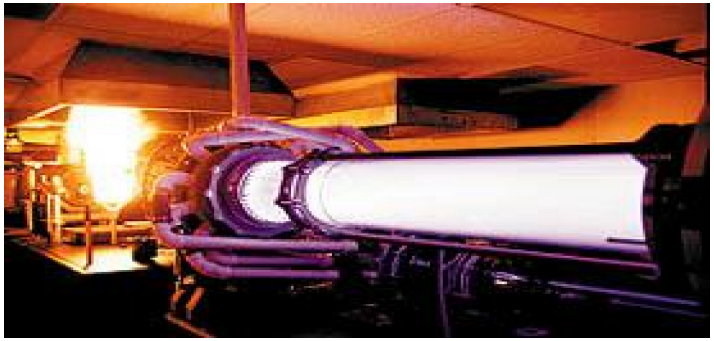
- The LHMEL facility uses high-energy continuous-wave CO_2 lasers to simulate nozzle throat heat flux in a laboratory environment
  - LHMEL facility is used to evaluate RSRM nozzle CCP material for pocketing propensity
  - LHMEL screening of STS-108 RH nozzle tag ends showed acceptable pocketing threshold behavior (material from Lot 3206, Roll 24B)
  - Residual CCP irradiated for development of new specimen holders exhibited unexpected pocketing erosion behavior (material from Lot 3206, Roll 27A)
  - Lot 3206 incorporates 67 rolls in 11 nozzles—only STS-108 RH contains Roll 27A material

Technical Issues/Special Topics

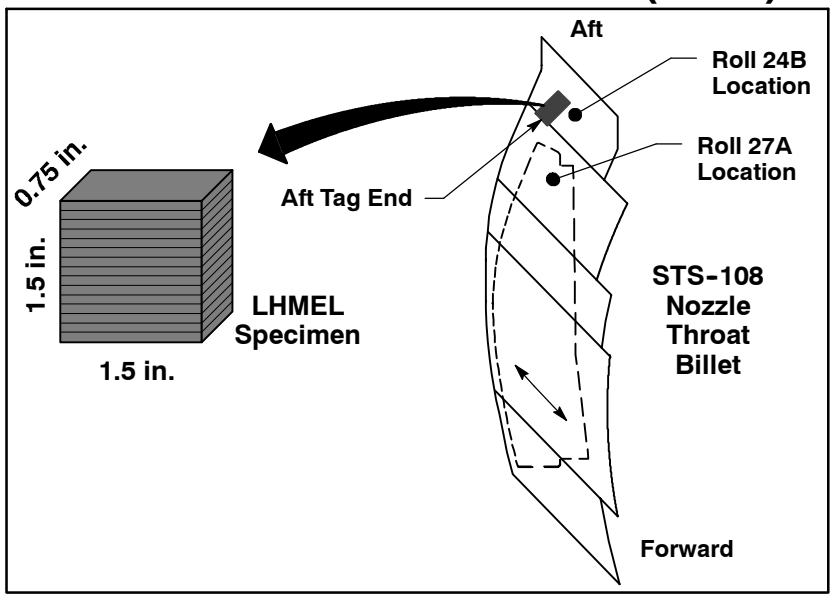
STS-108 RH Nozzle Throat Carbon/Phenolic Material Performance (Cont)

Background (Cont)

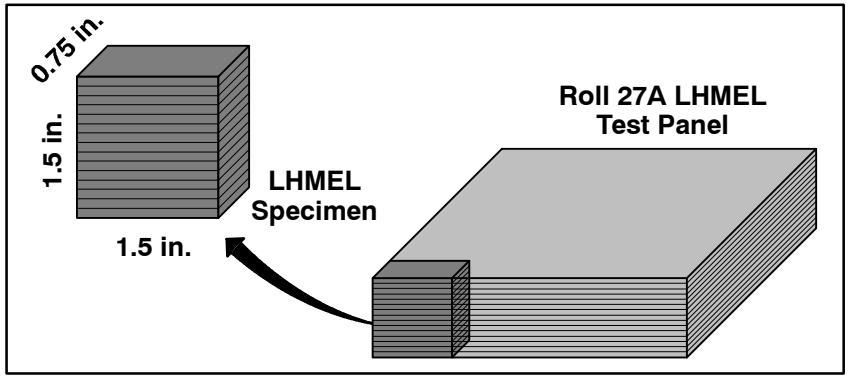
LHMEL Facility



- Tag end material taken from aft throat billet
- Five specimens irradiated
- Material acceptable for use if no more than one specimen out of five exhibits pocketing
- Pocket defined as local spalling ≥ 0.1 in. deep



Nozzle Throat Material Screening



LHMEL Specimen Holder Evaluation

Technical Issues/Special Topics

STS-108 RH Nozzle Throat Carbon/Phenolic Material Performance (Cont)

Discussion

- A fault tree approach was developed to investigate the performance of Roll 27A
  - No out-of-family process or test conditions were noted that would adversely impact expected material performance or suggest that material in current flight nozzles is any different from that previously flown
- Statistical assumptions inherent in the population of materials irradiated at low-threshold flux level were reassessed
  - Evaluation showed population was skewed by inclusion of a majority percentage of high-threshold material
    - Use of the overall population for evaluation of variation in low threshold material is not conservative
    - Extrapolation of bounding pocketing behavior from the skewed distribution is not conservative
- Testing efforts were initiated to better characterize the performance expectation of low-threshold CCP
  - Re-validate self-limiting pocketing behavior
  - Characterize self-limiting pocket depths

Technical Issues/Special Topics

STS-108 RH Nozzle Throat Carbon/Phenolic Material Performance (Cont)

Discussion (Cont)

- Forty-seven test specimens taken from panels and tag ends over multiple material lots including pocketed nozzles—all low-threshold materials

Specimen	CCP Source	Number in Population
Panel	Lot 3206, Roll 27A	14
Panel	Lot 3208, Roll 57A	2
Panel	Lot 3208, Roll 57B	2
Tag End (Lot 3206)	STS-111 RH (aft tag)	10
Tag End (Lot 3206)	STS-111 RH (forward tag)	9
Postburn Virgin Material	STS-79 RH (postfired nozzle)	10

All specimens, including Roll 27A panel, exhibited self-limiting pocketing behavior

- Standardized test conditions included laser radiance simulating initial RSRM heating environment in pocketing region
- Standardized specimen thickness and test duration

Technical Issues/Special Topics

STS-108 RH Nozzle Throat Carbon/Phenolic Material Performance (Cont)

Discussion (Cont)

- Low-threshold CCP material test effort demonstrated:
  - Self-limiting behavior (pocketing stopped within 30 seconds in all cases)
  - Pocket depths normally distributed
  - Performance of Roll-27A is within statistical expectations for low-LHMEL threshold material, both flown and non-flown
- Normal distribution and conservative nature of tests allows high-confidence bounding K-sigma pocket depth projection
  - 95-percent confidence level—99.865 percent of population captured
  - New bounding depth is 57 percent deeper than that used in previous flight rationale
- Thermal model used to assess effects of bounding case pocket depth was anchored to match prior pocketed nozzles
- Thermal analyses with increased bounding case pocket depth showed:
  - 0.75 in. of carbon-cloth material remaining (0.19 in. of virgin material) at end of burn
  - 63 seconds remaining burn time beyond the nominal 123-second motor burn time based on charring to the CCP/glass-cloth phenolic (GCP) interface
- Actual pocket depth distribution should not differ significantly from current flight/static test population

Technical Issues/Special Topics

STS-108 RH Nozzle Throat Carbon/Phenolic Material Performance (Cont)

Flight Rationale

- Throat pocketing on flight nozzles assessed to be a possibility
  - Normal manufacturing variation can produce low pocketing threshold CCP
  - No out-of-family process conditions noted that would adversely impact expected CCP material performance in STS-108 and subsequent nozzles
  - Low-threshold CCP with the same process pedigree as Roll 27A has flown and pocketed (STS-79) with adequate burn time remaining for safe flight
  - If pocketing occurs, erosion and char performance of the nozzle is not expected to differ significantly from the past flight and static test population
  - The pocketing process is self-limiting and remaining burn time beyond 123 seconds with K-sigma bounding case pocket depth is substantial
- STS-108 and subsequent are safe to fly

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STS–108 Readiness Assessment

Pending satisfactory completion of normal operations flow (per OMRSD), the RSRM hardware is ready to support flight for mission

STS–108

15 November 2001

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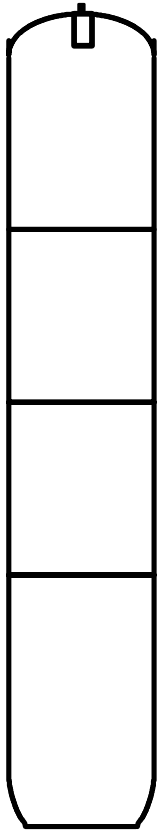
Current Flight Predictions

LCC and Contingency Temperatures for STS-108



Heater Location	LCC	Minimum Allowable Sensor Temperature*	
		LH	RH
Igniter	74°F	72°F	72°F
Forward Field Joint	80°F	63°F	65°F
Center Field Joint	80°F	66°F	71°F
Aft Field Joint	80°F	76°F	66°F
Nozzle-to-Case Joint	75°F	71°F	75°F

*Launch commit criteria (LCC) contingency temperature in the event of heater failure

Note: Calculation includes all standard repair conditions